AIR LIFT PUMPING AND WATER PURIFICATION[1]

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This paper is not written to discuss the principles of air-lift pumping, but it is advisable to call attention at the outset to the necessity, if success is to be attained, of choosing correctly the diameters of the water and air pipes for different lifts and submergences, and of obtaining a complete, intimate mixture of the air and water at the foot piece. If an air lift plant is properly designed and constructed it furnishes water continuously without interruption for a long period. For example, at Maywood, a suburb of Chicago, there is an air lift plant furnishing 700 gallons per minute from a single well, with a lift of over 300 feet. The compressor has been running twenty-four hours daily for four years, without other interruption than a stop of a few minutes each day for examination and occasionally for some adjustment. There has been no expense whatever for repairs.

There are occasions where the air lift can be used as an auxiliary to a high duty suction plant pumping from deep wells, as at Clinton, Ill., something over a year ago. There the water is obtained by suction from deep wells. For ordinary purposes a sufficient amount is delivered by this method, but for peak loads in the summer and in case of fire the supply was not sufficient. The water is drawn from half a dozen wells having a surface flow of limited volume. These are connected so as to flow into a surface reservoir, or may be direct-connected to the mains by means of suction pumps.

In order to be able to meet the heavy drafts, three of the wells were connected with the air lift system arranged to discharge into the reservoir, using the suction piping as a gravity flow line. One of the 8-inch wells had a natural artesian flow of about 150 gallons per minute. When under suction from the pumps, the pull-down was 20 feet, increasing the flow to 500 gallons per minute. With

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the air lift, its production was increased to 1035 gallons per minute, the pumping head being 50 feet below the surface. The other two wells, connected up in the same manner, showed a proportionate increase.

The efficiency of the air lift when operating under heavy lifts is illustrated by table 1, giving the results of two tests made at Galesburg, Ill., on plants installed by the author. One plant has been in operation for a year and the other about six months. Formerly the public supply was drawn from three deep and six shallow wells, with a combined yield of about 250 gallons per minute. This plant was expensive to operate. It was therefore decided to sink a new well, which furnished 450 gallons per minute, which was so satisfactory that a second well was sunk in another part of the city, which furnished 650 gallons per minute.

Well 1 was cased with 40 feet of 24-inch heavy steel casing, 106 feet of 20-inch, 130 feet of 16-inch, and 350 feet of 12-inch, the last being sealed into the rock. A 12-inch hole was then drilled to a depth of 1085 feet from the surface, where the diameter was reduced to 10 inches and the drilling continued, through the St. Peter's sandstone, to a depth of 1255 feet. It was then shot with two 200-pound charges of 100 per cent gelatin, covering the entire sandstone stratum, and cleaned out carefully. Ten-inch wrought iron pipe was next sealed into the top of the 12-inch pipe about 350 feet below the ground surface; this extends to within 3 feet of the top of the sandstone and keeps out of the well all water from strata overlying the St. Peter's formation. The air lift delivers the water into a small surface reservoir from which it is pumped into the mains under 40 pounds pressure by a centrifugal pump. On account of the heavy lift, an auxiliary starting device was installed at a depth of 481 feet, 8 inches.

The main features of the second well are also shown in table 1, from which it will be seen that this equipment also included an auxiliary starting device.

There is one feature of pumping water by the air lift which gives it special advantages where it is desirable to eliminate certain substances like sulphates or carbonates of iron which are in solution. When the air is thoroughly mixed with the water, the latter is aerated and certain of its undesirable constituents are thereby oxidized into forms which can be removed by filtration.

Carbonates of iron are more susceptible to treatment in this manner than are sulphates of iron. With the latter the water will probably need preliminary sedimentation before it goes to the filters and a small dose of lime may be needed to accelerate the sedimentation.

There are various methods of arranging the parts of one of these combined lifting and purification plants. The air lift may merely

TABLE 1

Results of tests of air lift installations in two wells at Galesburg, Ill.

	WELL 1	WELL 2
Depth of well	1252 ft.	1245 ft.
Diameter of well	40 ft. of 24-in.	360 ft. of 15 in.
Diameter of well	106 ft. of 20-in.	230 ft. of 14½ in.
Diameter of well	130 ft. of 16-in.	635 ft. of 13½ in.
Diameter of well	809 ft. of 12-in.	
Diameter of well	170 ft. of 10-in.	
Water pipe in well	235 ft. of 5-in.	204 ft. of 8-in.
Water pipe in well	331 ft. of 6-in.	213 ft. of 7-in.
Water pipe in well		190 ft. of 6-in.
Main air line	331 ft. of 2½-in.	600 ft. of 3-in.
Auxiliary air line	490 ft. of 1½-in.	500 ft. of 1½-in.
Static head from ground	186 ft.	190 ft.
Drop during pumping	118 ft.	157 ft.
Elevation above surface of outlet	7 ft.	7 ft.
Total lift	311 ft.	354 ft.
Operating submergence	262 ft.	253 ft.
Percentage of submergence	45.8 per cent	41.75 per cent
Depth of pump in well	566 ft.	600 ft.
Operating pressure	121 pounds	115 pounds
Starting pressure with auxiliary	149 pounds	135 pounds
Discharge per minute	450 gallons	650 gallons
Free air used per minute	450 cubic ft.	719 cubic ft.
Revolutions of compressor per minute.	179	214
Water horse power	35.5	58.2
Operating air horse power	94	148
Estimated efficiency	37½ per cent	39.3

discharge water from a well into the sedimentation basin of a purification plant from which it is pumped in the usual way. If the well is deep enough to give the necessary submergence and other conditions are right, the air lift can be arranged to lift the water into an elevated tank, which will also serve as a sedimentation basin, from which the water will pass by gravity through a pressure filter

into the water distribution mains. A third arrangement that is practicable under some conditions is to place the pressure filter in the line between the well and the elevated tank.

The practicability of using the air lift for installations like the last two is sometimes overlooked. They are not always possible, for the operating conditions must be right to enable them to be used satisfactorily. In the boosters generally used in these installations, the water discharged from the well is brought to a complete stop by striking what is called an umbrella separator in the booster. This throws the water to the bottom of the booster and allows the air to escape from the top. Nevertheless, owing to the intimate mixture of the air and water, which resembles an emulsion in appearance, considerable air is carried by the water discharged from the booster. While this air is beneficial, on account of its aerating properties, in the purification of the water, it is detrimental if the booster delivers water to long horizontal pipe lines, because the air will form pockets at high points. It is also detrimental where the water goes directly to pumps or condensers. Where such operating conditions exist the air must be removed by a separator.

THE CYCLONE SEPARATOR

In order to overcome the difficulties of carrying air over into long pipes because of complete emulsion and to insure perfect separation of the air and water, a special separator has been designed, consisting of a simple shell or cylinder with top and bottom. The combined air and water is discharged into the top and at one side at a tangent to the periphery, under high velocity from the well, causing it to swirl, effecting in this way a perfect separation of the air and water, the water leaving the separator from an outlet at the bottom tangent to the periphery and the air passing off at the top. The downward centrifugal action completely separates the air from the water, leaving the air quite dry and freeing the water entirely from air bubbles.